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# Barriers to research collaboration across disciplines: scientific paradigms and institutional practices

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Abstract. In a recent paper in this journal it was suggested that the conventional knowledge practices of disciplines are the fundamental obstacle to mutual understanding between academic experts. Such a position, we argue, underplays the institutional relationships that recreate expert and disciplinary divides. To demonstrate our case we discuss how in the UK the evolving relationship between the government and research councils has crucially altered the context for efforts to stimulate interdisciplinary research. Our analysis highlights the scope for changes in institutional structures and practices that would facilitate broader and more encompassing research into complex sustainability

## Introduction

problems.

Complex sustainability problems call for thinking and analyses that are broad and encompassing (Kates et al, 2001; Klein, 2004). Various strands of expertise may be relevant. In bringing together multiple perspectives, partial understandings are counteracted. A basic requisite must be scope for mutual or common understanding between different fields of knowledge.

It is important to be aware of what may inhibit or facilitate such mutual understanding. In a recent paper Robert Evans and Simon Marvin (2006) make the case that the fundamental obstacle is the knowledge practices of academic disciplines—specifically the distinct beliefs and identities that constitute individual disciplines which are threatened by, and therefore impede, efforts to combine scientific perspectives.

In this paper we want to raise other potential obstacles-to do with the institutional relationships that recreate expert and disciplinary divides—that are arguably both more salient and more tractable. We would want to claim at least that they furnish an alternative diagnosis of the specific failure of scientific collaboration that Evans and Marvin adduce, and allow for a less pessimistic prognosis of the prospects for interdisciplinary collaboration. Where we agree with Evans and Marvin is in the significance and difficulties of research collaboration that crosses over the macrosciences (the social sciences, the environmental sciences, the biological sciences, etc), and the focus of our paper is on what facilitates or inhibits such collaboration. We would maintain, however, that the challenge of working across disciplines in these circumstances is much more than about disciplinary barriers and crucially implicates the decisions, processes, and structures of research-funding organisations. Our alternative interpretation is based on a reinterrogation of the evidence and arguments that Evans and Marvin present, interviews and correspondence with key figures in UK science policy in the 1990s, as well as our own experience of running a large interdisciplinary research programme-the UK research councils' Rural Economy and Land Use Programme-which promotes holistic perspectives on rural sustainability (Lowe and Phillipson, 2006).

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#### Researching the sustainable city

Evans and Marvin (2006) review the conduct of major urban research programmes promoted by the UK research councils in the 1990s. They recount how initial aspirations for integrated research perspectives, transcending the social, natural, and engineering sciences (what they term "radical interdisciplinarity")<sup>(1)</sup> were eclipsed by a set of programmes, each one separately led by a different research council, including: the Engineering and Physical Sciences Research Council's (EPSRC's) Towards the Sustainable City Programme (established in 1993); the Economic and Social Research Council's (ESRC's) Cities and Competitiveness Programme (1996); and the Natural Environment Research Council's (NERC's) Urban Regeneration and the Environment Programme (1996). Through these separate programmes, it seems,

"radical proposals to research the city as a complex combination of science *and* technology *and* society contracted into more cognate collaborations that emphasised either science *or* technology *or* society" (Evans and Marvin, 2006, page 1009, original emphasis).

Evans and Marvin (2006) ascribe the failure to move towards radical interdisciplinarity to the different perspectives of the social, environmental, and physical sciences (ie the macrosciences) on the object of study—the city. This was not just a problem of different technical languages and terminology, but of the distinct outlook, beliefs, and identities of disciplinary specialists whose "shared paradigms... give meaning to their work" (page 1025).

Difficulties in seeking collaboration across the macrosciences were pronounced because the disciplines brought together were "characterised by very different paradigms, methods, and research approaches" (page 1010). The challenge of interdisciplinarity was thus "not merely a case of adding new knowledge, but also of questioning a discipline's 'cherished beliefs'" (page 1010). That questioning, it seemed, proved too much. As a consequence, there was a "movement from a radical interdisciplinarity that cut across research council boundaries to more limited forms of collaboration between cognate disciplines" (page 1010). The final, and "almost inevitable", outcome was that "the city is disciplined by the different research frameworks, which construct it in different ways" (pages 1025 - 1026).

## What's in a paradigm?

We would not want to deny the significance of disciplinary paradigms, nor underestimate the difficult practical challenges in achieving mutual understanding, creative exchange, or integration between them (see, for example, Bracken and Oughton, 2006; Marzano et al, 2006; Petts et al, 2008). Indeed, we see paradigmatic differences as central to interdisciplinary exchange. What we contest is their diagnosis that conventional disciplinary relationships between researchers are the fundamental obstacle. It is this tendentious conclusion which sends them down the route of scientific paradigms, epistemic cultures, and the sociology of knowledge for their explanation of the failure of discipline-bound researchers to connect.

<sup>(1)</sup> There is a great deal of debate in the literature over the use and definition of the term interdisciplinarity (and related terms, such as multidisciplinarity and transdisciplinarity). There seems to be common ground that interdisciplinarity differs from disciplinarity and multidisciplinarity in the emphasis it places on interaction and joint working, which brings the knowledge claims and conventions of different disciplines into a dialogue with each other, yielding new framings of research problems (Klein, 2004; Mourad, 1997; Petts et al, 2008). However, given that it is necessarily a condition that is contingent, it would seem futile to sharply prescribe what is or is not interdisciplinary research.

Firstly, we question the assumption of the boundedness of disciplinary practices and identities. Implicit in Evans and Marvin's (2006) account is a view of disciplines as fixed, homogeneous, and strongly bounded units that give clear, distinct, and unitary identities to disciplinary specialists. The strength of disciplinary loyalties is seen to configure individual researchers and their peers:

"Being a member of a particular discipline is ... a matter of becoming a particular kind of person" (page 1018).

The evidence from the sociology of science challenges these assumptions. Disciplines are not hermetic and homogeneous but are fluid and have permeable boundaries (Abbott, 2001). They are also marked by internal differences that are often deeply entrenched (Dogan, 1997; Galison and Stump, 1996). Thus, within a discipline there is not necessarily a common agreement on methods and theories or even a uniform terminology. What holds most disciplines together is a collective claim to authoritative understanding of certain problems or objects and an evolving nexus of institutional connections (Turner, 2000; Whitley, 2000).

If disciplines are not so fixed, rigid, or impermeable, then researchers themselves are even less bound by unitary identities. Many researchers move between disciplinary specialisms and may, at different times in their careers or even at the same time, adopt different disciplinary identities. Such movement indeed is seen as one of the main forces in the dynamic interplay between disciplines (Abbott, 2001; Dogan, 1997).

Paradoxically, Evans and Marvin (2006) themselves do not consider that disciplinary paradigms present such significant obstacles to cooperation inside macrosciences. Within, say, the social sciences or the physical sciences, they assert,

"these differences are often relatively minor, so that a set of disciplinary paradigms can coexist as variations around a set of core ideas or principles" (page 1025).

The implication would be that interdisciplinarity is relatively unproblematic within the macrosciences. However, each of these embraces multiple competing paradigms. If anything, the tensions and rivalry between paradigms within the same macroscience community—say, between institutional and neoclassical economics, or between holistic and genomic ecology—may be more intense, as they are much more directly competitive in presenting mutually exclusive conceptualisations of the same phenomena. Such differences mean that it is inappropriate to stretch the notion of a paradigm to apply to the macrosciences.

Secondly, we question the evidence that Evans and Marvin present to support their case. Two of the three urban research programmes from which conclusions about interdisciplinary working are drawn, the NERC and ESRC programmes, were exclusively environmental or social science endeavours, so could not furnish insights into the challenge of joint working between social and natural science communities. 'Radical interdisciplinarity' was, in contrast, central to the Clean Technology Programme,<sup>(2)</sup> and to the EPSRC's Towards the Sustainable City Programme that would emerge from it. That deliberately incorporated social science, with the objective

"to stimulate interdisciplinary, collaborative, user-oriented research intended to deliver practical tools for making cities more sustainable" (Cooper, 1997, page 1; quoted in Evans and Marvin, 2006).

<sup>&</sup>lt;sup>(2)</sup> The Clean Technology Programme was fundamentally a collaboration between the biological and engineering communities. It brought together the Agriculture and Food Research Council (AFRC) [what is now the Biotechnology and Biological Sciences Research Council (BBSRC)] and the Science and Engineering Research Council (SERC) (what largely became the EPSRC). Our understanding of the achievements of the programme was informed by an interview with its first chairman, the process engineer Roland Clift (19 July 2007).

Projects supported involved disciplinary contributions ranging from architecture, engineering, computing, physics, and climatology, to economics, planning, human geography, and psychology. The majority of the projects incorporating some social science were funded entirely by the EPSRC, with a handful jointly funded by the ESRC from its Global Environmental Change Programme.

Unfortunately, Evans and Marvin (2006) do not actually describe or evaluate the practice of interdisciplinarity that took place in the Towards the Sustainable City Programme, although they note that in many ways it was a success in prompting research collaborations that would not have happened otherwise (page 1018). The programme's formal evaluation—based on a survey of research project leaders and stakeholders—concluded that:

"Overall, the programme has successfully stimulated and matured a research community in the UK that is willing to undertake multidisciplinary, user-oriented research. This was a primary purpose of the programme. To this extent, the UK is now better placed to deal with the multi-faceted, inter-linked issues surrounding urban sustainability" (Cooper and Palmer, 1999, page 126).

Even so, Evans and Marvin (2006) judge this programme "not successful" in pursuing radical interdisciplinarity (page 1023). They base their judgment on the claim that the initiative's achievements in interdisciplinary working were not followed through in the final round of funding, which concentrated on the modelling of urban engineering processes.

While the evidence is thus not clear cut that conventional relationships between researchers were fundamental obstacles to change, other institutionally more powerful groups were implicated in the limited progress made towards interdisciplinarity in these various urban programmes. For example, while the EPSRC chose to fund some social science in its programme, the NERC did not do so.<sup>(3)</sup> Our third point of contention then concerns recognising the research funders as key arbiters of research and knowledge practices. The UK research councils do figure in Evans and Marvin's account, but in a secondary role that is portrayed as paradigm bound. Not only does this underplay their central role in research agenda setting, but it also offers limited insight into their imperatives and constraints.

We therefore suggest an alternative explanation for the unmet expectations for interdisciplinary research, one grounded in the institutional structures and practices of the research council 'system'—a subject which has received almost no critical attention in the literature, compared with the well-rehearsed academic institutional factors that may inhibit interdisciplinary working.<sup>(4)</sup> We recognise that the research councils are but one element in the larger institutional fabric of UK research and science policy, but we would argue that they should figure centrally in any rounded account of the political economy of interdisciplinarity. Other organisations with an active and influential interest in the division of intellectual labour, such as the

<sup>(3)</sup> The NERC's Urban Regeneration and the Environment Programme ambitiously sought to integrate strategically a range of physical science perspectives. Petts et al (2008) comment that the programme:

"was largely active within the boundaries of NERC's earth system sciences. ... [It] failed (despite discussions) to engage ESRC. ... Thus ... social, economic and political dimensions were left implicitly to the involvement of the user community, rather than being approached through inter-disciplinary working with social scientists" (page 595).

<sup>(4)</sup> These include, for example, opportunities for appropriate training, the availability of respected publishing outlets for interdisciplinary work, career progression prospects, and the status of interdisciplinary work within the Research Assessment Exercise (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2005; Petts et al, 2008; Rhoten, 2004; Tait and Lyall, 2001). professions (Cooper and Symes, in 2008), have also been neglected. Our intention here, though, is not to present a comprehensive institutional analysis but to open up an academic debate which, though intense, has become rather inward looking.

## The research council system

To achieve radical interdisciplinarity along the lines set down by Evans and Marvin would have required a willingness between the research councils to collaborate in sponsoring research. What is apparent, though, is that there was no common strategic commitment between them to a sustainable cities research agenda in the 1990s and no agreed basis on which to combine resources in pursuit of this topic, except for minor collaboration between ongoing programmes.<sup>(5)</sup> Otherwise, research that sought to integrate social and natural or engineering sciences would have had to operate across the different research councils with their separate funding streams, institutional rules, and scientific priorities. Given the institutional obstacles to be overcome, it is difficult to envisage how any extended interdisciplinarity could have been realised without a very strong, prior strategic commitment to it. One of those involved in formulating the Towards the Sustainable City Programme commented how, when

"We heard that, against our recommendation, the Sustainable City Programme was not to have a single pot for funding located between the two research councils involved, we judged that it wouldn't achieve the degree of inter-disciplinarity we aspired to (meaning the shared funding of disciplines drawn from right across research council boundaries)" (Ian Cooper, personal communication, 30 October 2007).

It is not even evident that the separate research councils each accorded the same high priority to the urban environment—a necessary condition for any joint research venture. The NERC and the EPSRC did have parallel and, in certain respects, complementary programmes which provided the basis for some joint working between them (Petts et al, 2008). However, when the ESRC launched its own urban programme, the focus was on competitiveness not sustainability. In these circumstances, the decision by the EPSRC to devote significant resources on its own account to funding interdisciplinary research involving social science was an extraordinary and audacious act.

What the fragmentation of urban research in the 1990s highlights more generally is a need for a deeper exploration of the institutional relations, allocative rules, and agenda-setting mechanisms of research-funding organisations. Their rules and priorities set the scope for both mainstream research and boundary-transgressing endeavours. In the UK, public funding for basic research is especially complex as it is channelled through separate research councils representing different fields of science.<sup>(6)</sup> Programmes to support interdisciplinary research require active collaboration between councils, and it is important to understand what factors inhibit or encourage collaboration. Such insights help us to interpret the shifting terrain for strategic interdisciplinary working through the period covered by Evans and Marvin's analysis.

<sup>(5)</sup> There was, for example, some joint funding of projects between the SERC's Clean Technology and the ESRC's Global Environment Change programmes, and between the NERC's Urban Regeneration and the Environment and the EPSRC's Towards the Sustainable City programmes. <sup>(6)</sup> Currently, there are seven research councils in the UK, covering: arts and humanities; biotechnology and biological sciences; engineering and physical sciences; economic and social research; medical research; natural environment research; and science and technology facilities. Individual councils have promoted studies of their own histories (see for example Austoker and Bryder, 1989; ESRC, 2005). There is also a limited international analytical literature on research councils (see, for example, Braun, 2003; Gulbrandsen, 2005; Stewart, 1995; van der Meulen, 2003).

There are several types of situation that demand researchers to work across council boundaries. Certain disciplines are actually transected by these boundaries. This is notably the case for those based on generic forms of analysis, rather than on substantive foci: for example mathematics, statistics, or philosophy. Other disciplines such as geography, psychology, and anthropology straddle the councils because they comprise both a social and a natural science dimension. To be between or across councils in this way may not be disadvantageous; indeed, it may open up additional funding opportunities. In other circumstances the divisions between disciplines that are represented by separate councils may themselves be quite arbitrary, for example the division between population biology (the purview of the BBSRC) and population ecology (the purview of the NERC). Many biologists would indeed find a home in a number of research council communities. Finally, there are those situations where cross-council and interdisciplinary working is required to address frontier fields (such as nanotechnology) emerging at the boundaries of disciplines and councils, or where there is an interest in consciously seeking to recursively operate across them. This could be in order to address a compelling societal problem, such as ageing or energy, that is falling between the gaps. Or there may be transdisciplinary developments which need to be handled through cross-council collaboration, such as the emergence of new methods or techniques like gene sequencing, lasers, computer modelling, biosensing, or nuclear magnetic resonance. These developments pose a challenge to many disciplines as well as eroding the boundaries between them.

The research councils, as nondepartmental public bodies established by royal charter, are first and foremost organisations that exist to promote their particular field of science. Through the central role of academics in the governance, assessment processes, and client base of the research councils, disciplines intrude in multiple ways into their constitution and operations. However, while each of the councils embraces a range of disciplines, they are in fact the institutional expressions of macroscience communities, and there has been a tendency for the councils to identify more with the macrosciences than with basic disciplines. Thus, the ESRC represents and is responsible for the health of the social sciences, just as the NERC is for the environmental sciences. The councils are indeed the arbiters of what constitutes these macroscience communities, with considerable implications for the status and prospects of individual disciplines (see, for example, Caswill and Wensley, 2007; Johnston, 2004). In addition, while they give varying emphasis in their internal allocative structures to the role of disciplines, there has been a broad tendency to move away from discipline-based allocations to topic-based or methodologically based ones, as part of a (not uncontested) movement away from discipline-based decision making.

While the way each research council seeks to structure its field may be distinctive and changing, all the councils are strongly oriented to maximising the resources for their own fields. This makes them both highly protective of what resources they have got and strongly competitive between themselves in winning additional and future funding from government. This competitiveness in the winning of funds and protectiveness in the spending of them systematically militates against support for research that falls across their boundaries (Petts et al, 2008; interview with Sir Howard Newby, Chairman of the ESRC 1988 – 94, 17 May 2007).

The question has occasionally been raised as to whether the UK should have a single research council, in line with other countries. However, the proposal has not generated widespread support across the science community, different sections of which evidently look to 'their' research council to protect and promote the interests of their field. Government has shrunk away from the suggestion of a unified council as too unwieldy and bureaucratic, but also probably from an instinct not to disturb too many vested and vocal interests (OST, 2001a).

Nevertheless, the councils are ultimately creatures of government in that they were established by government, which occasionally also reorganises its boundaries and, more immediately, holds the purse strings. Collaboration and competition between them have therefore been shaped by wider shifts in science policy. Since the late 1980s, successive additions to the science budget have effectively doubled the research councils' income. Extra funding has come with strings attached. In particular, there has been intensified government effort to steer the science base, with government increasingly looking to the research councils to pursue a more strategic and coordinated approach (HM Treasury, DfES, and DTI, 2004).

#### The changing governmental interest in cross-research council collaboration

We identify three main phases in the evolving relationship between government and the research councils that have shaped the context of cross-council collaboration since the 1980s: first, under Thatcherism, the ruling approach towards the research councils was one of 'arms-length independence', second, during the John Major years of the early and mid-1990s, the approach shifted to a much more active 'directed management' of the councils by government which was unprecedented; and, finally, under New Labour, there was a shift towards 'self-managed collaboration'. We recognise that there were complex changes occurring to the research councils both internally and externally over this whole period, not to mention periodic reorganisations of their respective domains. We do not take on that broader canvas here, but wish to make the simple point that the principles ruling the research council system have been transformed in this period, with major consequences for strategic interdisciplinary working between the councils.

In the 1980s the research councils had a relatively free rein in conducting blue-skies, basic research. They were, however, operating within a tightly restricted science budget, which essentially they carved up between them through a body called the Advisory Board for the Research Councils (ABRC).<sup>(7)</sup> This meant that competition between them was especially intense, but—with the ABRC as a buffer between the councils and the government—they were left free to foster their core fundamental sciences.

A few cross-council initiatives did emerge during this period where it was apparent that if they pooled their efforts the councils could bid for additional funding. However, the ambitious SERC-AFRC collaboration on the Clean Technology Programme was quite unusual. This particular initiative was triggered off by a request from the Treasury to the research councils as to how they might respond to the challenge put by Margaret Thatcher in her trailblazing green speech to the Royal Society in 1989. The high political profile of its provenance helps to understand the radicalism (and generous funding) of the programme which sought to recast the relationship between the biological and engineering communities around the green agenda. This and follow-on collaborations in the 1990s formed a bridgehead for specialists such as mathematical modellers to enter, and in some cases transform, certain biological research fields and

<sup>(7)</sup> Comprising heads of the research councils and a majority of independent members, its role was to advise the Department for Education and Science (DfES) on the size and distribution of the science budget. Essentially the independent members of the ABRC would agree the composition of the science budget following representations from the research council chief executives. This annual recommendation would be passed up through the DfES to ministers and the Treasury. David Edgerton and Kirsty Hughes (1989) analyse the Thatcherite approach to science and technology policy, while Rogers Williams (1988) characterises the administrative structures and policies of this period.

for molecular biologists to move into biotechnology and bioengineering. The Clean Technology Programme also funded early work in life-cycle analysis and sustainable production and consumption, and was a precursor of the EPSRC's Towards the Sustainable City Programme. The programme was procedurally innovative too. For example, it experimented with cross-council assessment procedures and pooling of funds, as well as with novel methods of setting research agendas that brought together diverse disciplines and stakeholders (interview with Roland Clift, 19 July 2007).

While this programme demonstrated what could be achieved by imaginative interresearch council leadership and cooperation, there was no wider imperative amongst the councils for interdisciplinary working. As Howard Newby (1993) commented:

"There is a lot of goodwill between the research councils to encourage greater co-operation [between social and natural scientists]. There is even a fair amount of understanding that each others problems are important. But however much goodwill and mutual understanding there is, it all seems somehow to slip through our fingers when we come to devising some common endeavour" (pages 1-2).

The outlook specifically of the ESRC was strongly coloured by the fact that, in the mid-1980s, as the Social Science Research Council, it had come very close to being abolished by the Thatcher government (Flather, 1987). Having been reprieved, it had concentrated on the task of rebuilding the basic scientific credentials of social science research.

There was a distinct change of outlook towards investment in public research after Thatcher's departure. The Major government moved to harness the science base to the government's agenda of improving wealth creation and quality of life. The 1993 white paper, *Realising Our Potential: A Strategy for Science, Engineering and Technology* (DTI, 1993), changed the relationship between government and the research councils. It led to a reorganisation of the research council system, including the establishment of the position of Director General of the Research Councils (DGRC) and the abolition of the ABRC. The new DGRC took over the responsibility for advising ministers on the allocation of funds to the councils. He negotiated the budgets directly with each of them and chaired a monthly meeting of their chief executives.

Overall, the changes were intended to give government greater influence over scientific priorities (interview with Sir Howard Newby, 17 May 2007). The new administrative arrangements breached the 1918 Haldane principle, which accorded autonomy to the science community in the spending of research funds. Sir John Cadogan, the first incumbent of the post of DGRC, explained that the changes transformed the research councils from being "isolated ... feudal baronies" by ensuring that "the chief executives of the Research Councils became my team" (House of Commons Science and Technology Committee, 2001, question 166). The increased steering of science was accompanied by an increasing science budget, which took some of the edge off the councils' intense competition over resources and sugared the pill of their diminished autonomy. In this way, the competition between the councils was not eliminated but was channelled towards the strategic concerns of the government.

To strengthen the strategic focus of their research, each council sought to reorient greater parts of their science agendas around potential users. While all the research councils retained strong blue-skies funding streams, there was a growing emphasis within each on directed (or themed) funding programmes such as the urban programmes that Evans and Marvin review. The emphasis in such programmes was on the councils looking outwards, to government, business, and industry, not on cross-council collaboration. The new rhetoric was of strategic research, stakeholders, and user communities. Technology Foresight, another central initiative of the white paper, would identify emerging and future technologies, as a basis for steering strategic research priorities.

This effort to bring research and development closer to (projected) users' needs demanded little in the way of cross-council initiative. If anything, a certain transgressive opportunism was encouraged amongst the research councils, to poach from their neighbours' domain in order to equip themselves adequately to conduct targeted programmes. One of those who framed the Towards the Sustainable City Programme has commented how he and others underestimated

"how predatory/open-minded EPSRC would prove to be about funding inter-disciplinary teams where significant inputs came from disciplines commonly identified as belonging to other research councils" (Ian Cooper, personal communication, 30 October 2007).

Likewise, just as the ESRC's Global Environmental Change programme had trespassed on NERC's traditional territory, so NERC launched its Urban Regeneration and the Environment Programme, which took it into the traditional haunts of the ESRC. NERC also began funding economic research in some of its institutes.

Technology Foresight would be relaunched in 1999 under New Labour as Foresight, with a broadened remit to encompass wider social and economic issues which might drive wealth creation or affect quality of life. Cross-council collaboration would be more central to achieving these modified aims. Under New Labour, although the science base was still subject to overall strategic steering by government, the previous emphasis on 'directed management' of the councils shifted towards a situation of 'self-managed collaboration', with the research councils taking more responsibility specifically for operationalising cross-council processes.<sup>(8)</sup> This culminated in 2002 in the creation of the partnership, Research Councils UK (RCUK), to facilitate working across the councils through harmonisation of their missions, systems, and cultures (OST, 2001a; 2001b).<sup>(9)</sup>

Interdisciplinary research and cross-council working were to receive a concerted push. The councils were persistently pressed to adopt standardised and common procedures, to facilitate cross-council research, but also to take a more strategic interest in frontier topics at or beyond their boundaries. The Office of Science and Technology which oversaw the research councils within government urged that

"Much of the most innovative work in science is being done at the boundaries between traditional subject areas. Collaboration between Councils to develop frontier research is increasingly important" (OST, 2001b, page 21).

The Treasury saw this as essential if research was to make its maximum contribution to society and affirmed that:

"We need to enhance a culture of multidisciplinary research in the UK and provide the underpinning infrastructure and funding mechanisms to support it. This is a critical challenge" (HM Treasury, DfES, and DTI, 2004, page 22).

<sup>(8)</sup> The DGRC withdrew from the detailed management and coordination of the research councils. In 2004, when Sir Keith O'Nions was appointed to the role, he argued for a review of the relationship between the DGRC and the councils to ensure that the DGRC was engaged in strategic matters consistent with the councils being able to offer independent advice to government, and for the day-to-day management of the councils, their accountability and cross-council issues, to be left to their chief executives. This was seen as a distinct departure from his predecessors' interpretation of the job (House of Commons Science and Technology Committee, 2004).

<sup>(9)</sup> RCUK was established following the Quinquennial Review of the Grant Awarding Research Councils in 2001 (OST, 2001a; 2001b) which took forward New Labour's Modernising Government agenda, one of the principal aims of which was to ensure policy making is joined up and strategic. The review drew attention to the lack of collective identity and scope for collective action across the councils and the widely perceived problem of how boundary and multidisciplinary research was being handled. The research councils took up the challenge. The NERC's (2000) *Strategy for Science* called for a breaching of the boundaries between natural, engineering, social, economic, and medical and health sciences. The ESRC's (2000) *Thematic Priorities* looked forward to interdisciplinary research between social and natural scientists particularly in the field of the environment and human behaviour.

Through successive multiannual spending reviews, additional resources were provided in the science budget for strategic and cross-cutting research programmes, including ones on energy, basic technology, brain science, e-science, stem cells, genomics, and rural economy and land use. The extent of cross-council collaboration and interdisciplinary research has varied between these programmes. Within a number of them (including those on energy, genomics, and e-science) there has been a considerable amount of parallel research effort between research councils with different degrees of coordination. Regarding efforts to integrate the approaches of separate macroscience communities, there seems to be (at least) two distinct models in operation, both of which are represented in current programmes within the broad sustainability field. On the one hand, there is the transgressive-council model embodied in the Sustainable Urban Environment Programme; on the other hand, there is the intercouncil model embodied in the Rural Economy and Land Use Programme.

The Sustainable Urban Environment Programme (set up in 2006) is very much a successor to the EPSRC's Towards the Sustainable City Programme, which in turn built upon the SERC's Clean Technology Programme. Besides engineering and physical sciences, these successive programmes, although almost wholly financed by the EPSRC, have funded research collaborations involving a range of social and environmental sciences. The EPSRC refers to these as multidisciplinary collaborations and it has a considerable track record of running such programmes on its own (it also engages considerably on intercouncil collaborations). The EPSRC is in a position to do so, because it has greater resources than the other research councils and, in deploying its funds, faces fewer constraints from established research communities with strong views about how 'their' research money should be dispensed (such as the NERC and the BBSRC have faced in the past with their tied research institutes). Its staff are thus given much greater latitude in setting up programmes and in seeking to orchestrate strategic research collaborations that appear functional to the desired outcomes. In part this reflects also an engineering mentality—one that seeks to bring together the appropriate mix of expertise to solve the problem at hand. The social science that is supported as part of collaborative consortia under such programmes tends to be of an instrumental nature-aiding the solving of engineering problems-with an emphasis on research that is methodologically focused and rigorous rather than conceptually cutting edge. While it is pragmatic in seeking out the appropriate social science inputs, and must not be seen to be excessively diluting its primary mission to sponsor engineering and physical sciences, over the years the EPSRC has built up its own applied social science communities in fields such as urban transport and sustainable energy production, through its own funded programmes.<sup>(10)</sup>

The Rural Economy and Land Use Programme (established in 2003) presents a contrasting model based in the joint funding of interdisciplinary research by three research councils: the ESRC, the BBSRC, and the NERC. It calls for closer scrutiny because of the novelty of the model which would seem to accord in certain respects with what Evans and Marvin envisaged. From the start of the programme there was a commitment to pool the funding, but also, crucially, the funding decision making.

<sup>(10)</sup>Some of these insights into the EPSRC multidisciplinary programmes come from an interview with Peter Hedges of the EPSRC (18 February 2008).

This sharing of authority required specific governance arrangements, including the establishment of a strategic advisory committee, with senior scientists nominated by each of the three research councils (plus representatives of major stakeholders), to oversee the direction of the programme; and a programme management group, with senior officers of the three councils, to steer the administration of the programme. To operationalise a pooled funding pot additionally necessitated bespoke cross-council procedures for grant applications and assessment. Then, in order to stimulate interdisciplinary working and integrated outcomes, there were further developments in programme management, including the appointment of an independent programme director to coordinate the research and internal and external communication activities: the provision of specific seed-corn funding mechanisms to support the building of novel interdisciplinary partnerships; and the establishment of a cross-council datasupport service (the first of its kind). These institutional innovations and procedural improvisations hybridised the processes and cultures of the three research councils and absorbed lessons from previous intercouncil collaborations. Their functionality can only be judged in relation to the research they facilitated. Every project was required to combine creatively natural and social sciences and to pursue an integrated approach to project design, management, and research methods. The choice of disciplinary combinations and the approach, form, and techniques of interdisciplinary integration were left open. The twenty-nine projects funded responded to this challenge in a variety of ways, such that the programme presents a kaleidoscope of interdisciplinary research methods (Lowe and Phillipson, 2006).

## Conclusions

In this paper, prompted by Evans and Marvin's account of the barriers to interdisciplinary working, we have described three main phases in the evolving relationship between the UK government and research councils that have shaped the context of cross-council collaboration and efforts to stimulate interdisciplinary research. We have shown how interdisciplinary working, enabled by cross-council collaboration, has become a key device in the increasing effort by government to steer the science base.

From this review it is possible to understand something of the dynamic and limitations of the research programmes that Evans and Marvin describe. Their analysis emphasises the apparent intractability of discipline-bound identities and beliefs as the chief obstacle to interdisciplinarity. However, from the experience of more recent research programmes, we can observe that, when research councils make a strategic commitment to collaborate, this can facilitate 'radical interdisciplinarity'. Such a commitment was notably absent from the urban research programmes mounted in the mid-1990s. Our analysis thus highlights the significance of institutional structures and practices that are demonstrably mutable. We would therefore want to challenge Evans and Marvin's gloomy prognosis of the prospects for interdisciplinary collaboration.

Our brief excursion into developments in UK science policy over the past twenty years has shown that the principles ruling the research council system have been transformed over this period, which has greatly altered the circumstances for strategic interdisciplinary working between the research councils. We have illustrated these shifts by reference to the urban programmes of the 1990s, as well as more recent sustainability programmes.

Our account draws attention to the role of government in setting the ground rules for the research council system, and could legitimately be criticised for downplaying the autonomous responses and internal practices and procedures of the councils themselves. The latter would be a crucial (and large) part of a fuller institutional analysis, but it falls outside the scope of the present note. We would however venture a few reflections.

First, a different take on the response to the vogue for strategically steered, stakeholder-orientated, and collaborative programmes would be that the research councils have shown an astute 'dynamic conservatism' in that most of the new demands they have taken on have been largely funded with new ('above the baseline') money. This has allowed all the councils to retain strong blue-skies programmes that have continued largely unchanged.

Such an interpretation, however, would discount the extent to which the research councils themselves have been in the vanguard in developments in science policy. Government enthusiasm for strategic research and for interdisciplinary and multidisciplinary working has been echoed within the research councils. One way in which this has been reflected is in the increasing identification of the research councils with their macroscience communities rather than their constituent disciplines. Thus the research councils have used strategic thematic programmes to reorient and reequip their disciplinary specialists. The top output for the NERC (2005) from its Urban Regeneration and Environment Programme was "a clearly recognisable urban science community" (page 10) which at the outset of the programme had been seen to be "fragmented" (page 3), emergent, and in need of "a greater degree of direction" (page 11). Likewise, the ESRC's Global Environmental Change Programme set out with the explicit purpose both to create a capacity for environmental social sciences in the UK and to position the ESRC as a leading funder of environmental research, by demonstrating that "environmental change was not just about the natural world but was also a major social issue" (ESRC, 2005, page 24). Arguably, the ESRC first had to create the conditions in which environmental economics, environmental politics, and environmental sociology could take root in the UK, before it could embark on bigger joint social – natural science challenges. The same could be said of the establishment of, say, environmental engineering or urban ecology as the EPSRC and the NERC respectively girded their macroscience communities for the sustainable research agenda. However we view such initiatives retrospectively, they do illustrate the research councils' role as active arbiters of their macroscience communities, not tied by disciplinary boundaries.

The successive research programmes led by the SERC-EPSRC in the field of urban sustainability stand out in this regard: from Clean Technology, through Towards the Sustainable City, and to the current Sustainable Urban Environment. Besides engineering and physical sciences, these programmes over a period of more than fifteen years have funded major research collaborations involving a range of social and environmental sciences that fall outside the formal purview of the EPSRC. It is an interesting question to what extent the programmes have built up their own extra-EPSRC research community, able to bring accumulated experience and self-reflection, to the quest for deeper and better integrated scientific collaborations, and how this is affecting the shape of the EPSRC's macroscience community. Internalising these interdisciplinary programmes within the one council, though, has meant that the lesson-learning experience has itself been internalised.

The Rural Economy and Land Use Programme presents a contrasting model of interdisciplinary support. Although its governance and administration seem comparatively cumbersome, the model strives to preserve the culture and procedures of the different research communities. Compared with the transgressive-council model, it helps to ensure that integration between different scientific perspectives is pursued transparently and not on unequal terms. In our paper we have sought to identify institutional practices and structures that can serve to hinder but also facilitate broader and more encompassing thinking and analysis on complex sustainability problems. Much more work is needed in this area. To date, there has been no systematic attempt to draw together experience from past interdisciplinary initiatives.

There is a larger objective to be pursued through such programmes than their substantive problems, and that is the inculcation of a greater reflexivity and accountability amongst the science community regarding the disciplinary and funding structures through which they pursue their work and careers. As it is, although researchers tend to be alert to ever-changing funding opportunities, most remain blithely ignorant of the decision-making, agenda-setting, and resource-allocation mechanisms of research funders and their paymasters, that are so instrumental in shaping the disciplinary landscape. By opening up discursive spaces between disciplines and funding bodies, interdisciplinarity could and should be part of a broader democratisation of science policy.

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